Synopsis V3.1
Heavy Ion SEE test of MSK5920-1.5RH from M.S. Kennedy

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I. Introduction

This testing is a preliminary survey of the single event destructive and transient susceptibility of the MSK5920-1.5RH low voltage dropout voltage regulator. The device was monitored for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Texas A&M University Cyclotron Single Event Effects Test Facility.

II. Devices Tested

The sample size of the testing was two devices. The samples devices were delidded by MS Kennedy. The devices tested had a Lot Date Code of TBD (cage code #51651).

The device is a hybrid device containing 2 active circuits, one bipolar transistor and one bipolar control circuit.

III. Test Facility

Facility: Texas A&M University Cyclotron Single Event Effects Test Facility, 15 MeV/amu tune).

Flux: 1×10^3 to 4×10^4 particles/cm^2/s.

Fluence: Most tests were run to a fluence of 1×10^7 p/cm^2 at the highest LET to check for destructive or functional events.

Ion	**LET (MeV•cm^2/mg)**
Ar	8.7
Xe	53.9

IV. Test Conditions

Test Temperature: Room Temperature
Power Supply (input) Voltage: 3.3V
Load: no load and 2A load

V. Test Methods

Test circuit, as shown in Figure 1, for the voltage regulator contains a power supply for the input voltage (set to 3.3 volts), an electronic load, and a digital scope for capturing any output anomalies. Once the programmable output is present and the load conditions are set, the digital scope is set to trigger on voltages that are above or below a predetermined threshold. The threshold was set to 100 mV for these tests.

Once The MSK5920-1.5RH receives the input voltage, it produces a regulated output (1.5 Volts). The detail of DUT bias is given in Figures 2 and 3. Bias condition shown in Figure 2 is close to the bias condition recommended by the manufacturer. Bias condition shown in Figure 3 uses a significantly lower output capacitor value than the value recommended by the manufacturer. The digital scope triggered for both voltage dropouts and over voltage conditions at the output terminal.

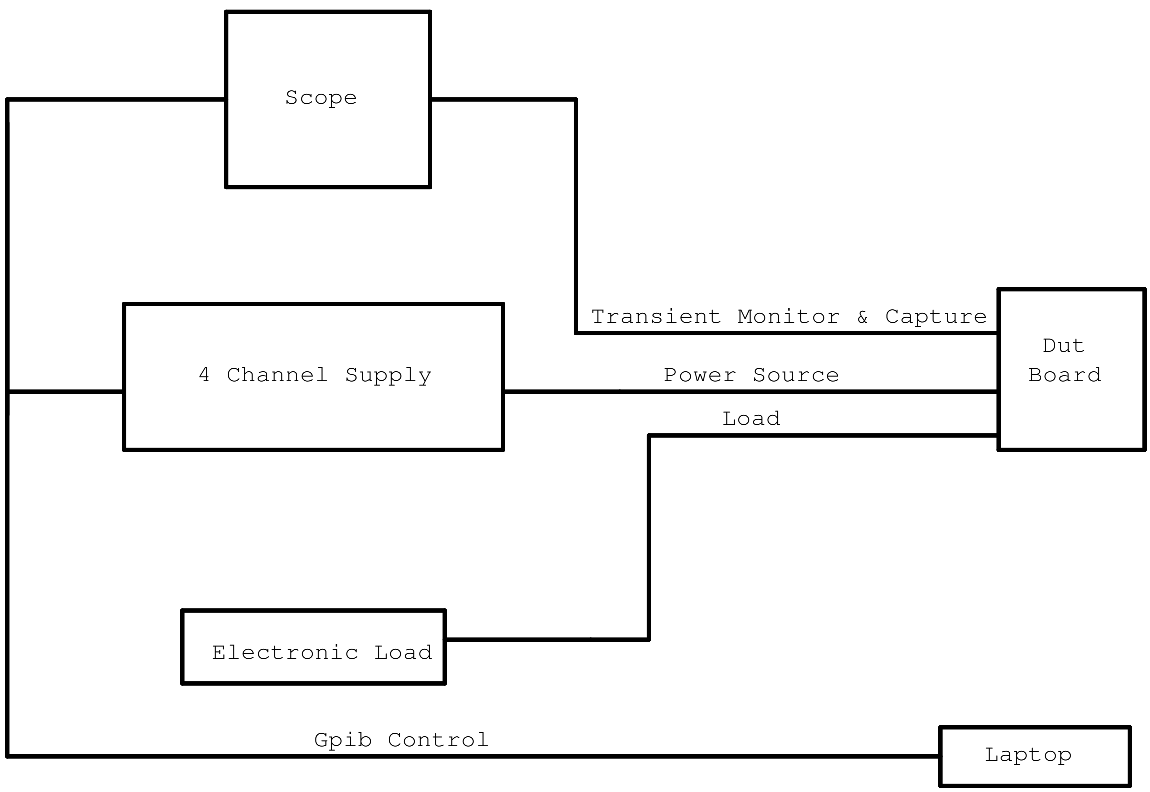

Figure 1. Overall Block Diagram for the testing of the MSK5920-1.5RH.

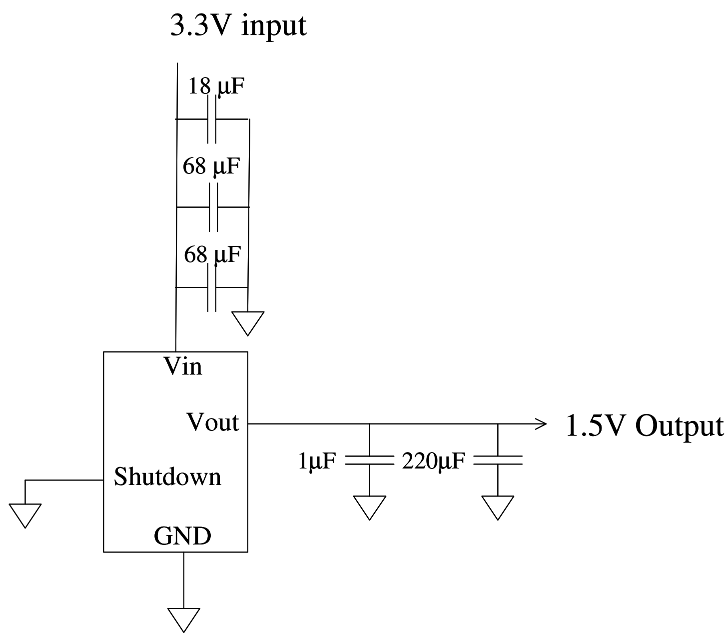

Figure 2. Block Diagram of the DUT board for the testing of the MSK5920-1.5RH, SN1286. Selected output capacitor values are as recommended by the manufacturer.

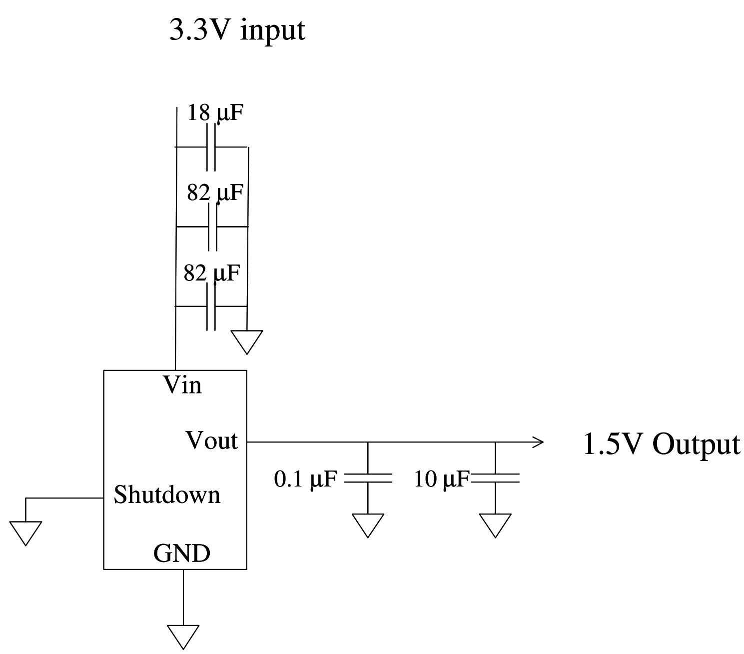

Figure 3. Block Diagram of the DUT board for the testing of the MSK5920-1.5RH, SN1287. Selected output capacitor values are significantly lower than those recommended by the manufacturer.

VI. Results

During testing the two MSK5920-1.5RH devices were irradiated with the Argon, and Xenon beams at normal incidence, 30 and 45 degrees (yielding an effective LETs of approximately 8.8, 12.4, 53.9, and 76.2 MeV•cm^2/mg). Transients from the MSK5920-1.5RH devices were encountered with the Argon and Xenon beam.

The two MSK5920-1.5RH Voltage Regulators were tested to measure the latchup and dropout cross sections under the above conditions. Each part was placed in the beam until a latch or dropout event occurred or 10^7 ions/cm^2. During our experiment, no latchup events occurred, yielding a threshold LET for latchup of > 76.2 MeV•cm^2/mg. One dropout event occurred on part SN1287 at the maximum LET of 76.2 MeVcm^2/mg when tested with the 2A load. A power cycle was necessary to recover from this condition. Figure 4 shows the shutdown. The output first goes back to 0V very quickly. Then, it comes back to 1.5V to return slowly to 0V. We don't know if a single event effect in the shutdown function circuitry was the cause of this shutdown. A thermal shutdown may also be a possibility because the thermal contact between the DUT and the board was very weak. Further testing is needed to investigate the cause of this shutdown.

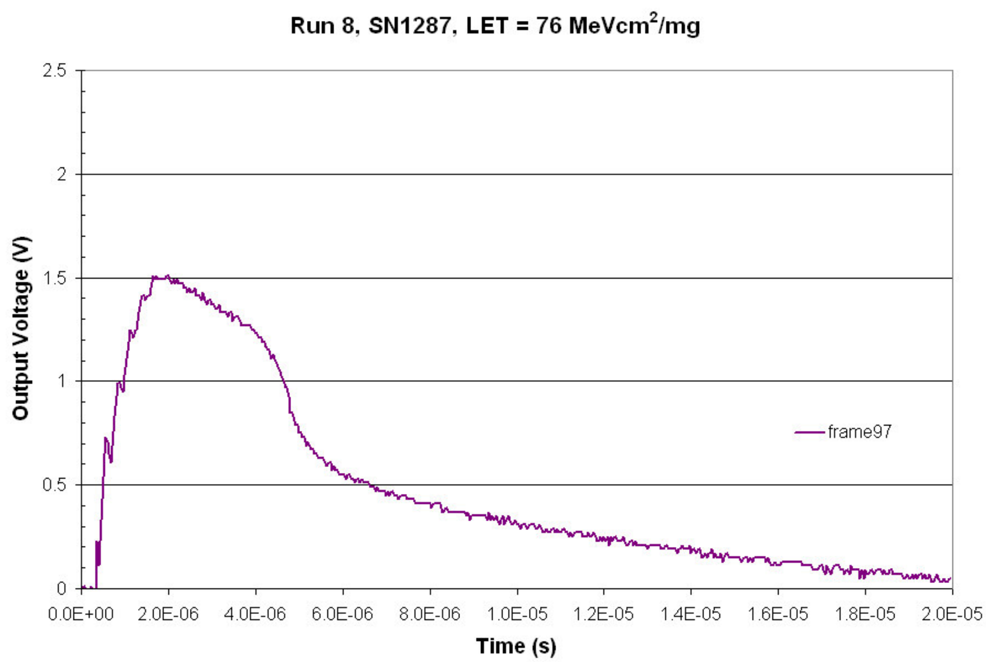

Figure 4: Output voltage during the shutdown event

The two MSK5920-1.5RH Voltage Regulators were also tested to measure the transient cross section under the above conditions. Each part was placed in the beam until transient events occurred or 10^7 ions/cm^2 was reached. If many transients occurred, then minimum of hundred samples were acquired. During our experiment, transient events did not occur up to the maximum LET of 76.2 MeVcm^2/mg when no load was applied at the device output.

During our experiments transient events happened when the 2A load was applied at the device output. An average cross section was determined for a given LET as the number of transient events observed divided by the total fluence of all the runs at that LET. The cross section results are presented in Figure 5. The LET threshold for transient is approximately 8 MeV•cm^2/mg and the saturation cross section is approximately 1.0 x 10^{-3} cm^2. We can see in Figure 5 that the part SN1287 has a higher SET cross-section. This may be due to the different input and output capacitors used. We can also see that the points taken with a 45 angle of incidence between the DUT and beam, do not give a higher cross-section as expected. This indicates a deep sensitive volume.

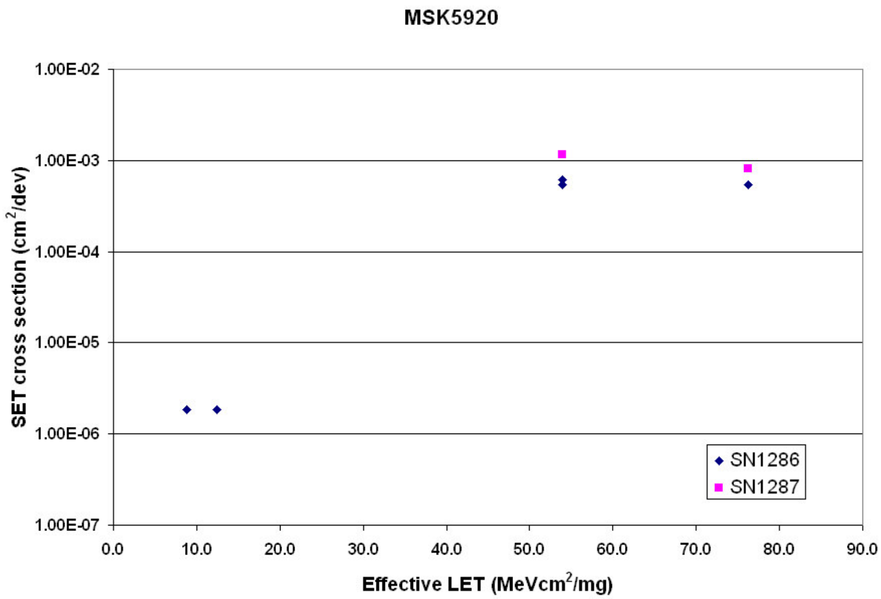

Figure 5. Transient cross section as a function of the effective LET for the MSK5920-1.5RH Voltage Regulators.

Figures 6 to 8 show sample transients encountered during testing. It is an oscillating waveform of amplitude decreasing with time. On part SN1286 that is biased with the output capacitor values recommended by the manufacturer, the maximum observed output voltage is 1.75V and the minimum output voltage is 1V. The device output is perturbed for about 5 µs. We can see in Figure 8 that the amplitude of transients is larger on SN1287 that is biased with smaller output capacitors. The maximum observed output voltage is 2V and the minimum output voltage is 1V, and the device output is perturbed for about 8 µs.

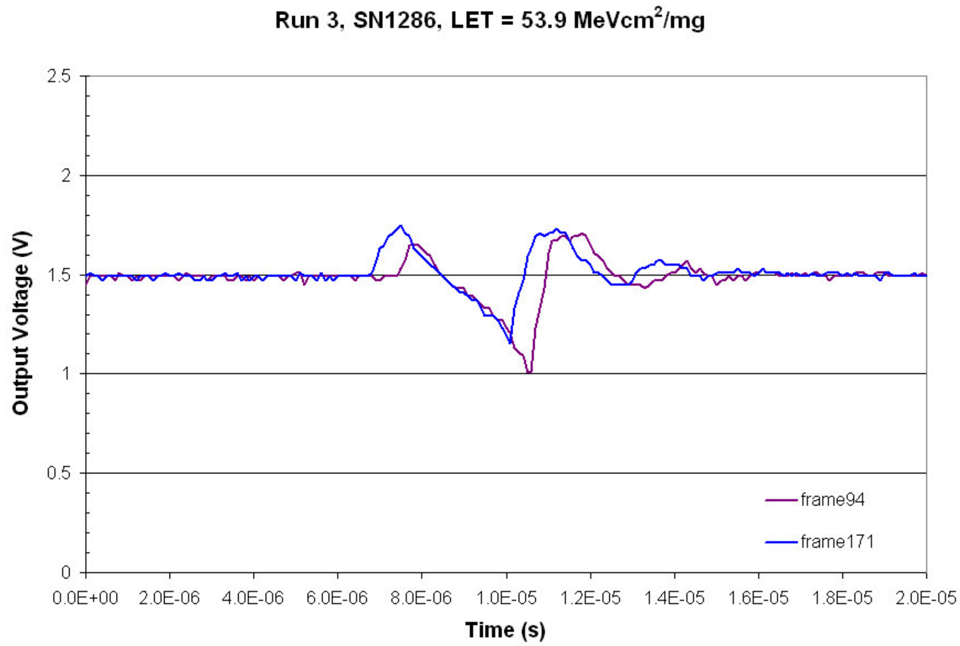

Figure 6. Transient taken from the output of the MSK5920-1.5RH SN1286 at high LET.

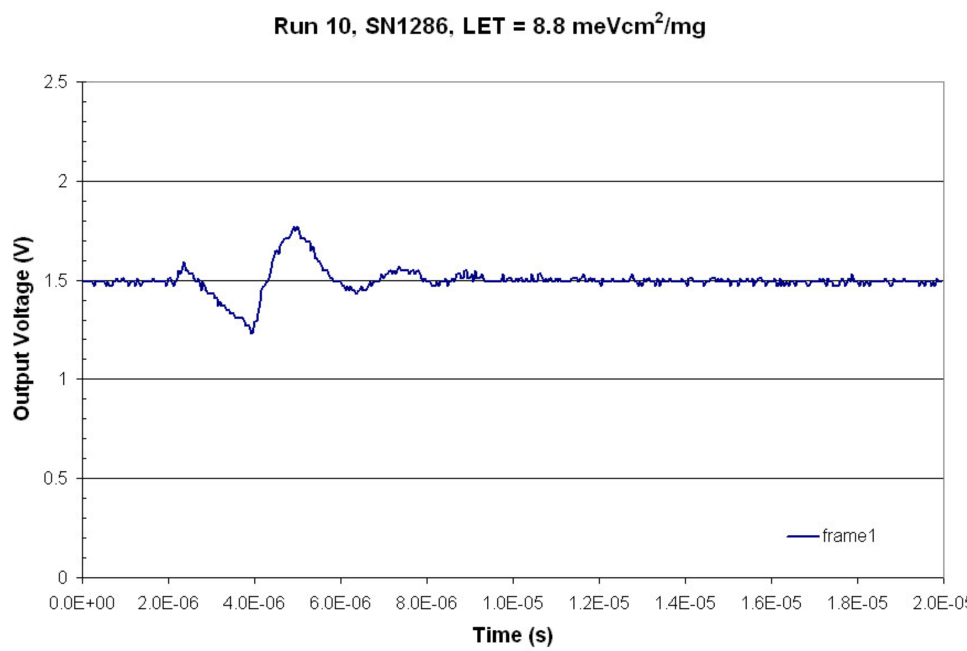

Figure 7. Transient taken from the output of the MSK5920-1.5RH SN1286 at low LET

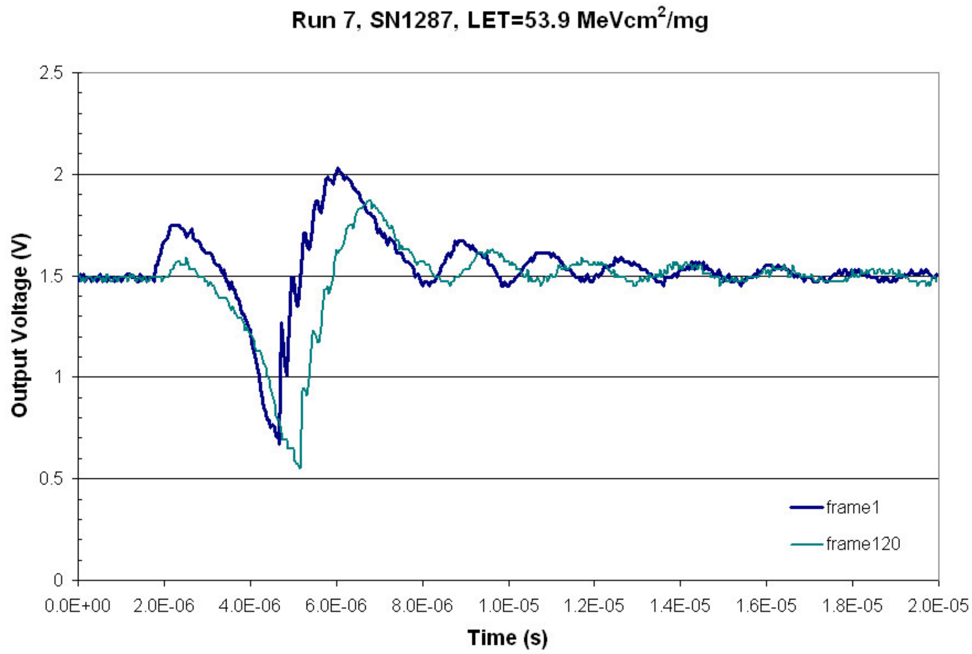

Figure 8. Transient taken from the output of the MSK5920-1.5RH SN1287 at high LET

VII. Recommendations

In general, devices are categorized based on heavy ion test data into one of the four following categories:

Category 1: Recommended for usage in all NASA/GSFC spaceflight applications.
Category 2: Recommended for usage in NASA/GSFC spaceflight applications, but may require mitigation techniques.
Category 3: Recommended for usage in some NASA/GSFC spaceflight applications, but requires extensive mitigation techniques or hard failure recovery mode.
Category 4: Not recommended for usage in any NASA/GSFC spaceflight applications.
Research Test Vehicle: Please contact the P.I. before utilizing this device for spaceflight applications

Further data is needed to categorize MS5920-1.5RH. Preliminary data indicate that it is either a category 2 or a category 3 device.

One possible application of these devices is powering of ACTEL RTAX-S FPGA core. ACTEL data sheet indicates an absolute maximum voltage of 1.6V and a maximum recommended operating voltage of 1.575V. Preliminary data show that MSK5920 will not satisfy these requirements in case of SET without additional filtering.

VIII. Further Test Requirements

We recommend laser SEE testing to investigate further the shutdown event, and the effect of input/output capacitor values on device sensitivity.

Appendix 1:

http://www.mskennedy.com/media/documents/5920RHrd.pdf

http://klabs.org/richcontent/LVDO_Regulators/mskennedy/5920-1.5/